Duct Leakage: If You Can Measure It, You Can Cut It

PIER Buildings Program

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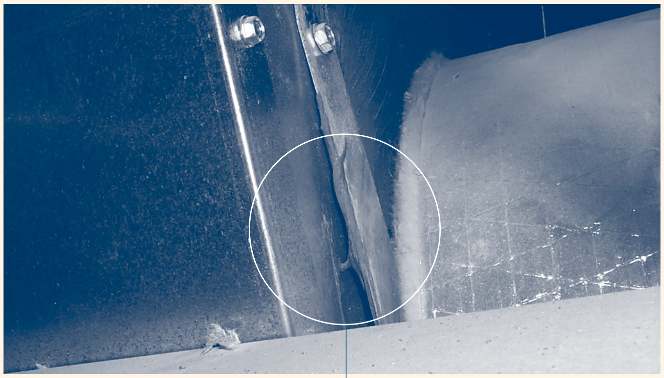
The Problem

The ductwork that distributes conditioned air throughout many large commercial buildings is often leaky, letting air out through cracks and gaps and increasing the energy consumption of supply- and return-air fans (**Figure 1**). Efforts to address this problem have been hampered by the lack of an accurate way to measure the leakage. In addition, sound methods for comparing the efficiencies of thermal distribution alternatives, such as air versus water or central versus distributed systems, have not been available.

Figure 1: A duct leak

At the point where a variable-air-volume box plenum (on the left) connects with a branch duct (on the right), the adhesive and metal plate have pulled away, creating a leak.



Leakage area

The Solution

To address the problem of duct leakage in large commercial buildings, researchers have now developed effective ways to measure leakage and have defined a metric—"HVAC transport efficiency"—that can be used to compare the relative performance of various types of thermal distribution systems. In addition, researchers have adapted Aeroseal, an effective residential duct-sealing system, for use in sealing leaks in large commercial facilities.

Features and Benefits

Three key activities can help to quantify and cut energy losses due to duct leakage.

Measuring leakage. Researchers tested two duct-leakage diagnostics and found that one reliably measured duct-leakage airflows. Monitoring airflows entering and exiting the duct system (**Figure 2**, next page) provides an accurate measurement of leakage and is much easier to accomplish and more accurate than trying to infer duct-leakage rates from pressurization tests. The major challenge in using this approach is being able to rapidly measure airflows exiting the multiple supply grilles that are found in a commercial building's air-distribution system. Researchers have now identified a system that is able to measure output airflows through 100 ventilation grilles in less than two hours.

Applying a new metric. To enable the industry to set standards for tighter distribution systems, researchers defined a new metric for distribution-system efficiency. HVAC transport efficiency indicates the overall efficiency of the thermal distribution system in a large commercial building. It's defined as the ratio between the energy used to transport heating and cooling media and ventilation air throughout the building, and the total thermal energy delivered to the various zones in the building. Transport energy includes all energy consumption by distribution fans, ventilation fans, and/or distribution pumps (excluding domestic hot water pumps). The thermal energy delivered is the sum of all zone loads. This ratio can be calculated both over the course of the year and under design conditions. It's useful for comparing the relative performance of various types of thermal distribution systems (air versus hydronic or distributed versus central systems) and for setting a baseline performance standard for all such systems.

Sealing leaks. To effectively seal leaky ducts in large commercial buildings, researchers modified a technology called Aeroseal, which has been used successfully in small commercial and residential buildings. The system features an adhesive aerosol spray that diffuses throughout the duct system, gradually building up into flexible seals at holes, cracks, and other areas of leakage. To enable the use of Aeroseal in large, complex ductwork systems, the researchers had to develop a new atomizer capable of delivering an increased flow of aerosol sealant into the ducts. In addition, when used in larger commercial buildings, the system requires multiple injection points for the sealant, in contrast to the single-location method used for homes or small commercial facilities.

Reducing duct leakage can have a significant impact on energy consumption and electricity demand. The researchers found that buildings with 15 percent duct leakage must use 25 to 35 percent more fan power to distribute air than if there were no leakage. In California, eliminating duct

Figure 2: Measuring the airflow exiting the distribution system

To accurately determine the amount of duct leakage in a building, the airflow entering *and* exiting the distribution system must be measured. This technician is measuring airflow at one of the many output points required to complete the overall calculation.

leakage airflows in half of all existing large commercial buildings could save about 560 to 1,100 gigawatt-hours annually (about $60 to $110 million per year, or the equivalent consumption of about 83,000 to 170,000 typical California houses) and about 100 to 200 megawatts in peak demand.

Applications

The enhanced Aeroseal technology can be used in new and existing large commercial buildings—those with over 50,000 square feet of floor area and a complex air-distribution system that features a large trunk duct with many smaller ducts connected to it.

California Codes and Standards

The 2005 California Title 24 compliance process for all new large commercial buildings requires calculation of the HVAC transport efficiency metric developed in this research as part of the alternative calculation methods. Title 24 previously had no provisions for crediting energy-efficient duct systems in these buildings.

What's Next

PIER is sponsoring a demonstration of the Aeroseal technology offered by Carrier Commercial Services in buildings on the University of California campus. That testing, which is scheduled to be completed by the end of 2005, will help determine what types of commercial distribution systems Aeroseal is best suited for and whether the technology is cost-effective.

Because problems associated with duct leakage in large commercial buildings have not been well-understood until now, mainstream building energy simulation programs such as EnergyPlus and DOE-2.2 have not included duct-leakage models. PIER is funding work to incorporate models for leakage in large duct systems in both the EnergyPlus and DOE-2.2 building simulation tools.

Collaborators

The organizations involved in this project include the Lawrence Berkeley National Laboratory, the U.S. Department of Energy, and Carrier Commercial Services.

For More Information

Reports documenting this project and providing more details may be downloaded from the web at www.energy.ca.gov/pier/buildings/projects/500-98-026-0.html.

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About PIER

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Arnold Schwarzenegger, *Governor*

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